THE

LONDON, EDINBURGH AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[THIRD SERIES.]

MAY 1844.

XLVIII. *On the practice of the Calotype Process of Photography.* By GEO. S. CUNDELL, *Esq.**

(1.) IN the year 1839 was published in France the invention of M. Daguerre, now so well known by the justly celebrated name of its author. Shortly afterwards, that of Mr. Fox Talbot, called "the Calotype," was published in England; kindred arts having for their object the production of permanent pictures by means of the camera obscura. If the comparative merits of the Daguerreotype and of the Calotype were to be judged of by the interest which each has excited, or by the progress which has been made in the practice of either, the English invention would justly be classed in a very subordinate rank; for, while the Daguerreotype was at once understood, and successfully practised, over the whole civilized world, most of the few persons who have attempted the sister art, after failing of success, have given it up in disappointment.

2. But notwithstanding the little progress the calotype has yet made, there is reason to believe that it only requires to be better known to be appreciated as an art not less beautiful than that of Daguerre, and that it is well deserving of a much greater share than it has yet received of the public attention. It requires but little apparatus; its materials are comparatively inexpensive; and it is possessed besides of the striking advantage, of yielding a great number of perfect copies from every original picture.

3. Had Mr. Talbot thought fit to publish directions for the details and refinements of his process, as minute and explicit as those given by M. Daguerre, his invention, it is probable, would now have stood in a very different position; there can be little doubt that it also, would by this time have been greatly

* Communicated by the Author.

improved upon; and it is with the hope of promoting its improvement, by removing some of the difficulties left at the threshold, and opening the way for the entrance of labourers into the vineyard, that I have been tempted to offer this little treatise to the public. They had been better pleased, no doubt, to have received such an offering from the hands whence it ought to have come; but with every respect for the distinguished author of the calotype, I hope I may without impropriety do that which he has omitted to do, by furnishing plain directions, from my own experience, by which calotype pictures *may* be produced, without much difficulty and with tolerable certainty and success.

4. The Daguerreotype plate owes its sensibility to the iodide of silver, obtained by exposing the metal to the vapour of iodine. The same compound, iodide of silver, is the foundation of the calotype also; but it is obtained by a "humid" process, by the decomposition of nitrate of silver, upon the surface of paper, by means of a solution of the iodide of potassium. It has been found that paper so prepared, when treated with gallic acid, becomes exceedingly sensitive; and that upon the slightest exposure to daylight, under particular treatment, it will become perfectly black and opaque. Hence its fitness and adaptation to receive the delicate but feeble impressions of the images formed in the camera obscura, which imprint upon it what has been called a "negative" picture, having the lights and shadows of nature reversed. This "negative," when fixed and rendered permanent, is used as a matrix; and, by a simple and well-known process, a great number of impressions may be photographically printed from it, representing objects not only in true light and shadow, but true also in relation to right and left.

5. Before anything good can be produced in calotype, the operator must be provided with a properly constructed camera obscura. The cameras met with in the shops are generally made after the French model, with nominally achromatic lenses, of the plano-convex figure, and of a short focus. Without presuming to disparage these, which no doubt will give a portion of well-defined picture in the centre of the field, sufficient for a single portrait, I would venture to recommend, on the authority of Dr. Wollaston, a lens of the meniscus figure, having the radii of its curves in the proportion of two to one.

6. He has shown, in an essay on the particular subject (in the Philosophical Transactions for 1812), that the meniscus figure, *when properly* "*stopped*," * is peculiarly adapted to the

* His improvement is a very striking one; and it seems odd, that the principal part of it, upon which the effect chiefly depends, his mode of stop-

camera obscura, from its property of producing a comparatively *flat* and focal field throughout the picture, when the picture is received upon a plane surface (§ 9). Without undervaluing the advantage of corrected aberration, it may well be doubted whether you do not lose more than you gain by the plano-convex figure, even though achromatic, from the impossibility of bringing its picture, when of any extent, to a tolerable focus. Achromacy is no doubt desirable; but in calotype, where the image is not to be magnified, it is by no means indispensable, as any one may prove who fairly tries the experiment; and the expense of a really achromatic lens of an adequate aperture must put it in a great degree out of the question. Perhaps the best substitute for it would be a lens of *blue* glass, which would transmit nearly the whole of the chemical rays to a common focus. But of whatever figure the lens may be, and of whatever colour, it will not be unimportant that the focus be considerably longer than that commonly used.

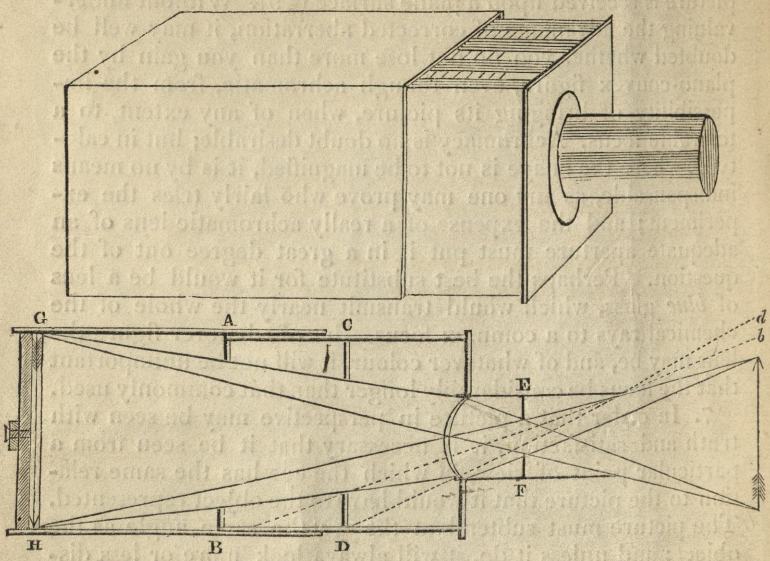
7. In order that a picture in perspective may be seen with truth and satisfaction, it is necessary that it be seen from a particular point of view, in which the eye has the same relation to the picture that it would have to the object represented. The picture must subtend at the eye the same angle as the object; and unless it do, it will always look more or less distorted and unnatural. The principle is well illustrated in the diorama, the illusion and the charm of which depend in no small degree upon the placing of the spectator at the proper height and distance; but the principle applies to all pictures in perspective, and to camera pictures in particular, which are wonderfully improved when placed at the proper distance from the eye. Calotype pictures are not intended to be looked at, and are seldom viewed, at a shorter distance than twelve inches; and in order that such a picture viewed at that distance may be seen in *true* perspective, the lens of the camera must be of twelve inches focus. In portraiture the effect may be less obvious than in architecture, or in general subjects; but there can be no doubt that a portrait taken by a lens of six inches focus, viewed at the distance of twelve inches, would lose a great part of any truth or likeness it might really possess.

8. For these reasons the lens ought not perhaps to be less than twelve inches focus; and, if mounted in the manner shown in the subjoined drawing, it will be found to be generally convenient.

There is no novelty in this construction, unless perhaps in the introduction of the diaphragms A B and C D, and in the elongation of the mouthpiece; both of which are useful in pro-

ping out and admitting the light, is precisely the part which (so far as I am aware) has been entirely overlooked in practice, and in every popular treatise on the subject.

tecting the picture from all external light, except that which emanates from the objects to be copied; the rays from the



direction *b* being intercepted at B, and those from *d* at D. The paper is placed between two plates of glass, introduced at the open end G H, and these are pressed together and secured in their place by means of a detached door having a revolving bar behind it, the extremities of which work in grooves in the sides of the outer case*.

9. By reference to the diagram, it will be seen that by means of the diaphragm or "stop" E F, the rays from the barb of the arrow are excluded from the upper and received only upon the lower half of the lens, upon which they fall at a comparatively high and *equal* angle of incidence. They are thus less refracted than they would otherwise be, and their focus is not only sharpened but elongated. By this means, the picture, instead of being formed in the usual curve, is formed much nearer to a straight line in the plane of the paper placed to receive it.

10. A lens of twelve inches focus ought to have an aperture of 2·4 inches. The diaphragm at E F (in which the principal virtue of the instrument resides) ought to be placed 1·5 inch in advance of the lens, and its opening ought not to exceed 1·2 inch. By using one of a smaller opening, a much finer image will be obtained, but at the sacrifice of light: at

* The instrument, much improved, may be had of Mr. Dennis, 118 Bishopsgate Street Within.

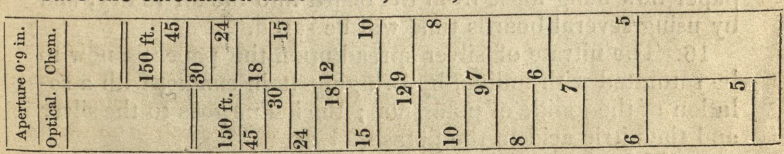
short distances, however, on account of the increasing divergency of the rays, only a small opening, admitting the mere centres of the pencils, can be used with advantage. The size of the plate glasses may be eight inches by six.

11. It must be observed of this camera, and of all others which are not achromatic, that there is a peculiar adjustment required of the focus, the not attending to which has been the cause of much failure and disappointment. The instrument must be adjusted to what has been appropriately called the *chemical* focus, which differs materially from the optical or visible focus, as will be seen by the following Table, in which the two are contrasted; the former being about one thirty-sixth part shorter than the latter for parallel rays, and for diverging rays in proportion.

Principal focus = 12 inches *.

Distance of object.	Visible focus.	Chemical focus.	Difference.
feet.	inches.	inches.	inch.
5	15·00	14·49	0·51
6	14·40	13·93	0·47
7	14·00	13·55	0·45
8	13·71	13·28	0·43
9	13·50	13·09	0·41
10	13·33	12·93	0·40
12	13·10	12·71	0·39
15	12·86	12·47	0·39
18	12·70	12·32	0·38
24	12·52	12·16	0·36
50	12·24	11·90	0·34
100	12·12	11·78	0·34

12. It will be found convenient to insert one or more strips of white wood in the sliding part of the camera, as shown in the drawing, and to graduate these with the foci produced by the different "stops" used at E F. This graduation is best done by first accurately determining the visible foci (by daylight) of two fiducial points near the extremities of the scale, by means of a test object and a magnifier, and then setting off by measure the calculated differences; thus, for a twelve-inch lens,



* For lenses of a different focus, the graduation will be in proportion, *at proportionate distances*; thus, for a lens of six inches, the spaces will be one-half the above, at *half the distances*.

When the instrument is thus graduated, the focus may be set in an instant (with an accuracy which is quite unattainable by the unassisted eye), by merely measuring the distance of the object if near, or by guessing at it if out of reach.

13. To produce a calotype picture there are five distinct processes, all of which, except the third (§ 25), must be performed by candle-light; they are all very simple, but at the same time all of them require care and attention. The first, and not the least important, is

14. *The Iodizing of the Paper.*—Much depends upon the paper selected for the purpose; it must be of a compact and uniform texture, smooth and transparent, and of not less than medium thickness. The best I have met with is a fine satin post paper, made by "R. Turner, Chafford Mill." Having selected a half sheet without flaw or water-mark, and free from even the minutest black specks, the object is to spread over its surface a perfectly uniform coating of the iodide of silver, by the mutual decomposition of the two salts mentioned in § 4. There is considerable latitude in the degree of dilution in which these salts may be used, and also in the manner and order of their application; but as the thickness and regularity of the coating depend upon the strength of the solution of nitrate of silver and upon the manner in which it is applied, I think it ought by all means to be applied first, before the surface of the paper is disturbed; and I am inclined to believe, that if the solution be used of double the strength suggested by Mr. Talbot, the coating will be found more perfect and continuous, and will produce better pictures. I use, accordingly, a solution of the strength of thirty grains to the ounce of distilled water.

15. The paper may be pinned by its two upper corners to a clean dry board a little larger than itself; and, holding this nearly upright in the left hand, and commencing at the top, apply a wash of the nitrate of silver *thoroughly*, *evenly* and *smoothly* with a large soft brush, taking care that every part of the surface be thoroughly wetted, and that nothing remain unabsorbed in the nature of free or running solution. Let the paper now hang loose from the board into the air to dry, and by using several boards time will be saved.

16. The nitrate of silver spread upon the paper is now to be saturated with iodine, by bringing it in contact with a solution of the iodide of potassium; the iodine goes to the silver and the nitric acid to the potash.

17. Take a solution of the iodide of potassium of the strength of 400 grains to a pint of water, to which it is an improvement, analogous to that of M. Claudet in the Daguerreotype, to add

~~fifty~~ 100 grains of common salt. He found that the chlorinated iodide of silver is infinitely more sensitive than the simple iodide; and by this addition of common salt, a similar, though a less remarkable, modification is obtained of the sensitive compound. Pour the solution into a shallow flat-bottomed dish, sufficiently large to admit the paper, and let the bottom of the vessel be covered to the depth of an eighth of an inch. The prepared side of the paper having been previously marked, is to be brought in contact with the surface of the solution, and, as it is desirable to keep the other side clean and dry, it will be found convenient, before putting it in the iodine, to fold upwards a narrow margin along the two opposite edges. Holding by the upturned margin, the paper is to be gently drawn along the surface of the liquid until its lower face be thoroughly wetted on every part; it will become plastic, and in that state may be suffered to repose for a few moments in contact with the liquid; it ought not however to be exposed in the iodine dish for more than a minute altogether, as the new compound, just formed upon the paper, upon further exposure would gradually be redissolved. The paper is therefore to be removed, and, after dripping, it may be placed upon any clean surface with the wet side uppermost until about half dry, by which time the iodine solution will have thoroughly penetrated the paper and have found out and saturated every particle of the silver, which it is quite indispensable it should do, as the smallest portion of undecomposed nitrate of silver would become a black stain in a subsequent part of the process.

18. The paper is now covered with a coating of the iodide of silver; but it is also covered, and indeed saturated, with saltpetre and with the iodide of potassium, both of which it is indispensable should be completely removed. To effect the removal of these salts, it is by no means sufficient "to dip the paper in water;" neither is it a good plan to wash the paper with any considerable motion; as the iodide of silver, having but little adhesion to it, is apt to be washed off. But the margin of the paper being still upturned, and the unprepared side of it kept dry, it will be found that, by setting it afloat on a dish of clean water, and allowing it to remain for five or ten minutes, drawing it gently now and then along the surface to assist in removing the soluble salts, these will separate by their own gravity, and (the iodide of silver being insoluble in water) nothing will remain upon the paper but a beautifully perfect coating of the kind required.

19. The paper is now to be dried; but while wet, do not on any account touch or disturb the prepared surface with "blotting-paper," or with anything else. Let it merely be

suspended in the air, and, in the absence of a better expedient, it may be pinned across a string by one of its corners. When dry it may be smoothed by pressure. It is now "iodized" and ready for use, and in this state it will keep for any length of time if protected from the light. The second process is that of exciting, or

20. *Preparing the Paper for the Camera.*—For this purpose are required the two solutions described by Mr. Talbot, namely a saturated solution of crystallized gallic acid in cold distilled water, and a solution of the nitrate of silver of the strength of fifty grains to the ounce of distilled water, to which is added one-sixth part of its volume of glacial acetic acid. For many purposes these solutions are unnecessarily strong, and unless skilfully handled they are apt to stain or embrown the paper; where extreme sensitiveness therefore is not required, they may with advantage be diluted to half the strength, in which state they are more manageable and nearly as effective. The gallic acid solution will not keep for more than a few days, and only a small quantity therefore should be prepared at a time. When these solutions are about to be applied to the iodized paper, they are to be mixed together, in equal volumes, by means of a graduated drachm tube. This mixture is called "the gallo-nitrate of silver." As it speedily changes and will not keep for more than a few minutes, it must be used without delay, and it ought not to be prepared until the operator is quite ready to apply it.

21. The application of this "gallo-nitrate" to the paper is a matter of some nicety. I doubt if it be possible to apply it successfully with *brushes*; and it appears to me, that one application of the gallo-nitrate as completely unfits a brush for a second, as the dipping of a sheet of paper in ink would unfit it for writing upon. It will be found an improvement to apply it in the following manner:—Pour out the solution upon a clean slab of plate glass, diffusing it over the surface to a size corresponding to that of the paper. Holding the paper by a narrow upturned margin, the sensitive side is to be applied to the liquid upon the slab, and brought in contact with it by passing the fingers gently over the back of the paper, which must not be touched with the solution.

22. It has been recommended at this stage, "to let the paper rest for half a minute, and then to dip it into water and dry it with blotting-paper," which I apprehend has been the fruitful cause of much failure and disappointment, by the staining and embrowning of the paper, and by the partial removal of its sensitive surface.

23. As soon as the paper is *wetted* with the gallo-nitrate, it

ought instantly to be removed into a dish of water; five or ten seconds at the most is as long as it is safe at this stage to leave the paper to be acted upon by the gallo-nitrate; in that space of time it absorbs sufficient to render it exquisitely sensitive. The excess of gallo-nitrate must immediately be washed off, by drawing the paper gently several times under the surface of water, which must be perfectly clean; and being thus washed, it is finished by drawing it through fresh water, two or three times, once more. It is now to be dried in the dark in the manner described in § 19, and when surface-dry, it may either be placed, while still damp, in the camera, or in a portfolio, among blotting-paper, for use. If properly prepared, it will keep perfectly well for four and twenty hours at least, preserving all its whiteness and sensibility.

24. The light of a single candle will not injure the paper at a moderate distance; but the less the paper, or the exciting solution, is unnecessarily exposed, even to a feeble candle-light, the better. Common river or spring water answers perfectly to *wash* the paper, distilled water being required for the silver solutions only. Stains of "gallo-nitrate," while recent, may be removed from the fingers by a little strong ammonia, or by the cyanide of potassium. The third process is that of

25. *The Exposure in the Camera*,—For which, as the operator must be guided by his own judgement, few directions can be given, and few are required. He must choose or design his own subject; he must determine upon the aperture to be used, and judge of the time required, which will vary from a few seconds to three or four minutes. The subject ought, if possible, to have a strong and decided effect; but extreme lights, or light-coloured bodies, in masses, are by all means to be avoided. When the paper is taken from the camera, very little, or more commonly no trace whatever, of a picture is visible until it has been subjected to the fourth process, which is

26. *The bringing out of the Picture*,—Which is effected by again applying the "gallo-nitrate" in the manner directed in § 21. As soon as the paper is wetted all over, unless the picture appear immediately, it is to be exposed to the radiant heat from an iron, or any similar body, held within an inch or two by an assistant. It ought to be held vertically, as well as the paper; and the latter ought to be moved, so as to prevent any one part of it becoming dry before the rest.

As soon as the picture is sufficiently brought out, wash it immediately in clean water to remove the gallo-nitrate, as directed in § 23; it may then be placed in a dish by itself, *under* water, until you are ready to fix it. The most perfect pictures are those which "come out" before any part of the paper be-

comes dry, which they will do if sufficiently impressed in the camera. If the paper be allowed to dry before washing off the gallo-nitrate, the lights sink and become opaque; and if exposed in the dry state to heat, the paper will embrown; the drying therefore ought to be *retarded*, by wetting the back of the paper, or the picture may be brought out by the vapour from hot water*. The fifth and last process is

27. *The Fixing of the Picture*,—Which is accomplished by removing the sensitive matter from the paper. The picture, or as many of them as there may be, is to be soaked in warm water, but not warmer than may be borne by the finger; this water is to be changed once or twice, and the pictures are then to be well-drained, and either dried altogether or pressed in clean and dry blotting-paper, to prepare them to imbibe a solution of the hyposulphite of soda, which may be made by dissolving an ounce of that salt in a quart (forty ounces) of water†. Having poured a little of the solution into a flat dish, the pictures are to be introduced into it one by one; daylight will not now injure them; let them soak for two or three minutes, or even longer if strongly printed, turning and moving them occasionally. The remaining unreduced salts of silver are thus thoroughly dissolved, and may now, with the hyposulphite, be entirely removed, by soaking in water and *pressing* in clean white blotting-paper, alternately; but if time can be allowed, soaking in water alone will have the effect in twelve or twenty-four hours, according to the thickness of the paper. It is essential to the success of the fixing process, that the paper be in the first place thoroughly penetrated by the hyposulphite, and the sensitive matter dissolved; and next, that the hyposulphite compounds be effectually removed. Unless these salts are completely removed, they induce a destructive change upon the picture, they become opaque in the tissue of the paper, and entirely unfit it for the next, which is

28. *The Printing Process*.—The picture being thus fixed, it has merely to be dried and smoothed, when it will undergo no further change. It is however a *negative* picture (§ 4), and if it have cost some trouble to produce it, that trouble ought not to be grudged, considering that you are now possessed of a matrix which is capable of yielding a vast number of beautiful impressions. I have had as many as fifty printed from one, and I have no doubt that as many more might be obtained from it.

29. The manner of obtaining these impressions has been so

* I now find that a horizontal jet of *steam* answers better than anything I have yet tried.

† Specific gravity 1014.

often described, and there are so many different modes of proceeding, that it may be sufficient to notice very briefly the best process with which I am acquainted. Photography is indebted for it to Mr. Alfred Taylor, the eminent chemist, whose pamphlet on the subject will supply every detail. His solution is made by dissolving one part of nitrate of silver in twelve of distilled water, and gradually adding strong liquid ammonia until the precipitate at first produced is at length *just* re-dissolved.

30. Some paper is to be met with, containing traces of bleaching chlorides, which does not require any previous preparation; but in general, it will be found necessary to prepare the paper, by slightly impregnating it with a minute quantity of common salt. This may be done by dipping it in a solution in which the salt can barely be tasted, or of the strength of from thirty to forty grains to a pint of water. The paper, after being pressed in clean blotting-paper, has merely to be dried and smoothed, when it will be fit for use.

31. The ammonio-nitrate of silver is applied to the paper in the manner described in § 15; and when perfectly dry, the negative picture to be copied is to be applied to it, with its face in contact with the sensitive side. The back of the negative picture being uppermost, they are to be pressed into close contact by means of a plate of glass; and, thus secured, they are to be exposed to the light of the sun and sky. The exposed parts of the sensitive paper will speedily change to lilac, slate-blue, deepening towards black; and the light, gradually penetrating through the semi-transparent negative picture, will imprint upon the sensitive paper beneath a *positive* impression. The negative picture, or matrix, being slightly tacked to the sensitive paper by two mere particles of wafer, the progress of the operation may from time to time be observed, and stopped at the moment when the picture is finished.

32. It ought then, as soon as possible, to be soaked in warm water, and fixed in the manner described in § 27.

33. In these pictures there is a curious and beautiful variety in the tints of colour they will occasionally assume, varying from a rich golden orange to purple and black. This effect depends in a great degree upon the paper itself; but it is modified considerably by the strength of the hyposulphite, the length of time exposed to it, by the capacity of the paper to imbibe it, and partly, perhaps, by the nature of the light. Warm sepia-coloured pictures may generally be obtained by drying the paper, by pressure, and making it imbibe the hyposulphite supplied in liberal quantity.

The paper of "I. Whatman, Turkey Mill," seems to give pictures of the finest colour, and, upon the whole, to answer

best for the purpose; and the successors of that gentleman, the Messrs. Hollingsworth, being so obliging as to prepare some paper with a little salt added to the sizing material, it is to be hoped, from its requiring no trouble or preparation injurious to its surface, that the demand for it will be such as to induce them in future to manufacture it as an article of commerce.

If the chemical agents employed be pure, the operator, who keeps in view the *intention* of each separate process, and either adopting the manipulation recommended, or improving upon it from his own resources, may rely with confidence upon a satisfactory result.

London, February 1, 1844.

XLIX. *On the Killas Group of Cornwall and South Devon; its relations to the subordinate formations in Central and North Devon and West Somerset; its natural subdivisions; and its true position in the scale of British strata.* By the *Rev.* David Williams, *Corresponding Member of the Royal Geological Society of Cornwall**.

I NOW exhibit to the Society maps, coloured geologically, from Bridgewater in Somersetshire to the Land's-end in Cornwall, with a section, from the Foreland on the Bristol channel to Lantioc bay, east of Fowey on the English channel, to show the superposition of the Cornish killas with regard to all the subordinate formations with which it is inseparably associated, and the four natural subdivisions into which it resolves itself by characteristic mineral and organic types, which are persistent throughout their entire range. This great and important classification has forced itself upon me by the constant repetition of the same successions in every traverse I have made of the killas country from sea to sea.

The innumerable minute details of strike and dip which I have registered from north to south and from east to west, fully convince me that the Cornish killas in the ascending order crowns a magnificent consecutive series such as I have illustrated on the map and section, a series however (complete and perfect as it is in all its particulars) which manifestly constitutes only a part of some vast system as yet unfolded.

I formerly subdivided the entire group into ten component members, the nethermost of which was the Cannington Park limestone near Bridgewater; but many circumstances have since induced me to suspect that, though geographically it

* From the Annual Report of the Royal Geological Society of Cornwall, 1843. Communicated by the Author, and with corrections by him.